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(71) Applicant
Era Patents Ltd

(Incorporated in the United Kingdom)

Cleeve Road, Leatherhead, Surrey, KT22 7SA,
United Kingdom

(72) Inventor
Charles Edmund King

(74) Agent and/or Address for Service
Gill Jennings & Every
53-64 Chancery Lane, London, WC2A 1HN,
United Kingdom

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(54) Green tape

(57) A green tape, in the form of a layer of substantially uniform thickness, is composed of a dielectric material and an inorganic binder.

The dielectric material may be e.g. alumina, silica, lead borosilicate glass or alumina borosilicate glass.

The inorganic binder may be e.g. selected from phosphates, silicates, borates, polyphosphates, polysilicates polyborates or polyacids of a transition metal.

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GREEN TAPE

FIELD OF THE INVENTION

The present invention relates to green tapes, their
5 production and use.

BACKGROUND OF THE INVENTION

Green tapes are used in the production of multichip
capacitors and hybrid circuit chips. Such products can
be produced by screen-printing each of the alternating
10 layers of dielectric and conducting layers. However,
screen-printing of the dielectric often leaves pinholes
which can only be covered by superimposition of
screen-printed materials.

It may therefore be preferred, and it is often
15 convenient, to screen-print a metal on to a pre-formed
green tape which consists essentially of a particulate
dielectric material and a binder. The green tapes are
produced by doctoring a suitable composition including a
diluent on to an inert material, followed by slow drying.
20 The dried tapes are flexible and can be removed from the
inert material.

In the past, organic binders have been used to
provide green strength by forming a self-supporting and
flexible matrix holding the 'permanent' solids content.
25 By permanent is meant the particulate matter of
dielectric which give the fired tape the characteristic
dielectric properties.

After construction of the multi-layer product, it is
compressed, usually at an elevated temperature, and then
30 subjected to burnout. Burnout is caused by firing at
600-1000°C, during which process the organic binder
constituent is allowed to burn off prior to the sintering
and densification stages. However, substantial
difficulty in processing occurs because of the reluctance

of organic binders to leave the product completely and cleanly during the 'burnout' stage.

Processing difficulties arise as a result of retained carbonaceous material leading to the reduction 5 of certain metal oxides. Metal oxide reduction by carbon to give carbon monoxide or carbon dioxide can lead to blistering and poor adhesion in multi-layer circuits. Also volatilisation and redeposition of low melting point metals formed by reduction can occur in unwanted areas. 10 Moreover the large volume of binder content used in the manufacture of green tapes will generally lower the overall densification during firing, resulting in substantial porosity. If high density products are necessary then a significant reduction in volume will 15 occur during the firing process. Large dimensional changes lead to difficulty in alignment if subsequent screen printing operations are to be carried out on the fired product.

SUMMARY OF THE INVENTION

20 A layer according to the invention (which for convenience may be termed a "green tape") is of substantially uniform thickness and of a composition which comprises a dielectric material and an inorganic binder. The invention thus avoids the use of organic 25 binders.

DESCRIPTION OF THE INVENTION

A green tape of the invention may be produced by applying the composition in admixture with a diluent on to an inert substrate, levelling the composition to the 30 substantially uniform thickness, drying the composition, and (if desired) removing the layer of the dried composition from the inert substrate. The inert substrate is a layer of, for example, Mylar.

The dielectric or 'permanent' component is e.g. a 35 dielectric compound such as a fine powder frit of lead

borosilicate glass. The amounts of the various constituents as applied may be, for example, 10-70% by weight binder solids, 5-45% by weight diluent and 5-85% by weight of the dielectric component. The dried green 5 tape may comprise 9-94% binder solids and 6-91% dielectric.

The binder is preferably a phosphate, silicate, borate, polyphosphate, polysilicate or polyborate or a polyacid of a transition metal. Most of these materials 10 are polymeric in nature to some extent. The term "polyacid" includes heteropolyacids such as tungstosilicic acid.

Especially preferred inorganic binders are a) potassium polyphosphate and b) aluminium acid phosphate 15 which in an aqueous or organic system provide the necessary rheological characteristics and when dried the required 'green strength' for the green tape. Potassium polyphosphate $(KPO_3)_n$ is an example of a generic group of mono and mixed metal polyphosphates and may be made by a 20 variety of methods of which a simple route applicable to laboratory production is the thermal dehydration of potassium dihydrogen orthophosphate (KH_2PO_4) . After an appropriate time at temperature the melt is quenched to give soluble long-chain polyphosphate. Aluminium acid 25 phosphate is also made by a variety of methods of which the mixing of fine alumina powder with phosphoric acid is the preferred example. A molar ratio of $P_2O_5 : Al_2O_3$ of between 1 : 1.5 and 3 : 1 may be used. However, preference is given to lower ratios.

30 Water and/or a volatile organic compound may be used as a diluent. Organic diluents, by their nature, are completely removed during the drying process.

The binder component (a) or (b) above when in a suitable diluent provides the necessary viscosity and 35 rheological properties for application and doctoring, and

on drying off excess water forms a matrix binding the particulate permanent constituent together, to form a flexible, solid green tape. Drying at 25-200°C may be accomplished using batch or belt ovens in air or an inert atmosphere. The green tape at this stage is able to receive a screen printed layer of a conductor pattern. The green tape is also sufficiently surface active to enable lamination of successive layers of dielectric, which may be accomplished using a uniaxial press, the procedure being carried out at room temperature. On firing, the inorganic binder constituent and various dielectric components form a robust and dense structure.

Firing of green tapes or of multilayer dielectrics containing an inorganic binder may be accomplished using conventional firing profiles, generally bell-shaped, with a peak temperature between 600°C and 1100°C depending on the sintering characteristics of the permanent phases.

In accordance with the invention, the co-firing of multi-layer laminated green tape in air or neutral atmospheres may be accomplished using inorganic binders without the problems of burnout attendant on the use of organic binders.

The following Examples illustrate the invention. Percentages are by weight.

25 Example 1

A dielectric slurry was made using an aqueous solution of aluminium acid phosphate having a molar ratio $P_2O_5:Al_2O_3$ of 2:1. A quantity of this solution mixed with silica powder was used to formulate a slurry suitable for casting green tape by a conventional doctor blading process. The slurry consisted of 22% silica, 39% hydrated aluminium acid phosphate and 39% water. A removable backing strip of acetate sheet was used to support the cast slurry. The cast tape was dried in air at 70°C and the acetate sheet removed. It was then fired

in a belt furnace with a conventional bell-shaped profile of 90 minutes with 10 minutes at peak of 900°C. The resultant fired structure was dense and robust.

Example 2

5 A dielectric slurry was made using an aqueous solution of aluminium acid phosphate having a molar ratio $P_2O_5:Al_2O_3$ of 2:1. A quantity of this solution mixed with powdered alumina borosilicate glass was used to formulate a slurry suitable for casting green tape by a
10 conventional doctor blading process. The slurry consisted of 40% glass, 39% hydrated acid phosphate and 21% water. A removable blacking strip of acetate sheet was used to support the cast slurry. The cast tape was dried in air at 70°C and the acetate sheet removed. It
15 was then fired in a belt furnace with a conventional bell-shaped profile of 90 minutes with 10 minutes at peak of 900°C. The resultant fired structure was dense and robust.

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CLAIMS

1. A layer of substantially uniform thickness, of a composition which comprises a dielectric material and an inorganic binder.
- 5 2. A layer according to claim 1, in which the inorganic binder is selected from phosphates, silicates, borates, polyphosphates, polysilicates and polyborates.
3. A layer according to claim 1, in which the inorganic binder is a polyacid of a transition metal.
- 10 4. A layer according to claim 1, in which the inorganic binder is selected from potassium polyphosphate and aluminium acid phosphate.
5. A layer according to any preceding claim, in which the dielectric material is selected from alumina, 15 lead borosilicate glass and alumina borosilicate glass.
6. A layer according to any preceding claim, which is 250 to 1000 μm thick.
7. A layer according to claim 1, substantially as herein described.
- 20 8. A process for producing a layer according to any preceding claim, which comprises applying the composition in admixture with a diluent on to an inert substrate, levelling the composition to the substantially uniform thickness, drying the composition, and (if desired) 25 removing the layer of the dried composition from the inert substrate.
9. A multi-layer dielectric which comprises, in alternation, (a) layers according to any of claims 1 to 7 or of layers produced by a process according to claim 8, 30 and (b) conductor material.